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ABSTRACT

Several implications for the understanding of the Darwinian revolution follow from an analysis of the role of colloquial language and prudential reason in Charles Darwin's quest for a theory of evolution. First, the term "natural selection" is not merely or even primarily a technical term and thus cannot be understood accurately apart from the circumstance for which it was designed. Second, an analysis of Darwin's inventional logic invites the expansion of the concept of scientific reason to include timing and a sense of the appropriate. Third, Darwin's rhetoric challenges the received notion that clarity or univocacy is the norm or goal of scientific language. Fourth, any attempt to distinguish Darwin's process of "discovery" from his process of "justification" on the ground that the former is private, subjective, and imaginative while the latter is public, objective, and falsifiable is itself falsifiable--for Darwin's reasoning cannot be accounted for by setting aside his language. Both before and after the "Origin," Darwin originated not so much a theory as a family of theories, each with distinct species and subspecies, and each in response to a particular occasion. (Fifty-five notes are included.) (RS)

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by John Angus Campbell

The Van Zelst Lecture
in Communication

May 24, 1990

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Foreword

The Van Zelst Research Chair in Communication was established at Northwestern University's School of Speech in 1981 with an endowment from Mr. and Mrs. Theodore W. Van Zelst. The rotating fund permits a professor to devote a year to research on an important issue in communication. The gift also provides for an annual lecture. This lecture, the dissemination of research findings, and the interaction of students and faculty with the visiting professor are designed to increase understanding of significant trends in the field of communication.

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John A. Campbell is associate professor of speech communication at the University of Washington, where he has taught since 1968. He received his bachelor's degree from Portland State University and his master's and doctoral degrees from the University of Pittsburgh.

Professor Campbell's numerous essays focus primarily on the rhetorical dimensions of Darwin's campaign for evolution. Two of these, "Darwin and *The Origin of Species*: The Rhetorical Ancestry of an Idea" (*Speech Monographs*, March 1970) and "Scientific Revolution and the Grammar of Culture: The Case of Darwin's *Origin*" (*Quarterly Journal of Speech*, November 1986), received the Golden Anniversary Award of the Speech Communication Association. His essays have also appeared in *Victorian Studies*, *Studies in Burke and His Time*, and *Rhetorica*, and as chapters contributed to books. He spent part of his sabbatical year (1986–87) at the Darwin archive in Cambridge and is presently doing research for a book (University of Wisconsin Press) tentatively entitled *Charles Darwin: Rhetorician of Science*.

Professor Campbell has served on the editorial board of *The Quarterly Journal of Speech* and currently serves on the boards of *Rhetorica* and the *Western Journal of Speech Communication*. He served as coeditor of an issue of *Rhetorica* focusing on the rhetoric of science and was guest editor of a special summer 1990 issue of *Western Speech* on rhetorical criticism.

On the Way to the Origin: *Darwin's Evolutionary Insight and Its Rhetorical Transformation*

by John Angus Campbell

Delivered at Northwestern University, May 24, 1990

Darwin's *On the Origin of Species* was published on November 24, 1859.[1] The basic insight that gave Darwin the core of what became the theory of natural selection first occurred to him in late October 1838, a little over two years after he had returned from his celebrated round-the-world voyage on the *HMS Beagle* (from 1831 to 1836), and 15 months after he had opened his first notebook on transmutation (in July of 1837).[2] In the fourth chapter of the *Origin*, Darwin spelled out the concept he had been working on for 20 years and had foreshadowed in the preceding three chapters. In a letter Darwin sent to John Murray, his publisher, he referred to the chapter as "the keystone of my arch."[3]

Chapter 1, "Variation under Domestication," described variations in domestic animals — sheep, pigeons, cows, horses, tomatoes, pears — such as one might find in any European or American farm. Chapter 2, "Variation under Nature," argued that the plenitude of variation one finds under domestication is matched by the plenitude of variation in nature. Chapter 3, "The Struggle for Existence," explained that when understood in light of the plenitude of variation, Malthus's law of population — that food supply advances arithmetically, but population advances geometrically — results in only the animals and plants best adapted to their settings surviving. Chapter 4 completed the conceptual path along which Darwin guided his reader by presenting natural selection as the consequence of familiar — indeed, utterly unremarkable — processes. The key passage reads as follows:

> As man can produce and certainly has produced a great result by his methodical and unconscious means of selection, what may not nature effect? Man can act only on external and visible characters: nature cares nothing for appearances, except insofar as they may be useful to any being. She can act on the whole machinery of life. Man selects only for his own good; Nature only for that of the being which she tends. Every selected character is fully exercised by her, and the being is placed under well-suited conditions of life. Man keeps the natives of many climates in the same country, he seldom exercises each selected character in some peculiar and fitting manner; he feeds a long and a short beaked pigeon on the same food; he does not exercise a long-backed or long-legged quadruped in any peculiar manner; he exposes sheep with long and short wool to the same climate. He does not allow the most vigorous males to struggle for the females.

> He does not rigidly destroy all inferior animals, but protects during each varying season, as far as lies in his power, all his productions. He often begins his selection by some half-monstrous form; or at least by some modification prominent enough to catch his eye, or to be plainly useful to him. Under nature, the slightest difference of structure or constitution may well turn the nicely-balanced scale in the struggle for life, and so be preserved. How fleeting are the wishes and efforts of man! How short his time! and consequently how poor will his productions be, compared with those accumulated by nature during whole geological periods. Can we wonder, then, that nature's productions should be far 'truer' in character than man's productions; that they should be infinitely better adapted to the most complex conditions of life, and should plainly bear the stamp of far higher workmanship?
>
> It may be said that natural selection is daily and hourly scrutinising, throughout the whole world, every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good; silently and insensibly working, wherever and whenever opportunity offers, at the improvement of each organic being in relation to its organic and inorganic conditions of life. We see nothing of these slow changes in progress, until the hand of time has marked the long lapses of ages, and then so imperfect is our view into long past geological ages, that we only see that the forms of life are now different from what they formerly were.[4]

This passage does more than present a concept. In keeping with the pattern of the chapters that preceded it, Darwin embedded his central insight in a preexisting common world of thought and feeling. Never in the *Origin*, and only late and partially in his subsequent campaign for evolution, did Darwin ever give the core concept of his argument as a logical proposition shorn of its colloquial language and associations.

Any scientist today who described natural selection as Darwin did would be laughed at. Today when we present the core of Darwin's theory of natural selection, we do so in formal language. The following example is representative:

> 1. Organisms vary, and these variations are inherited (at least in part) by their offspring.
> 2. Organisms produce more offspring than can possibly survive.
> 3. On the average, offspring that vary most strongly in directions favored by the environment will survive and propagate. Favorable variation will therefore accumulate in populations by natural selection.[5]

The difference in the kind and the amount of information carried by these two accounts — Darwin's version and our version of his theory — is striking. Our version puts Malthus's laws of population in the foreground and downplays the metaphor of selection. (The word "selection" appears in it once, and this reduces immensely the cognitive work we require as compared with Darwin's metaphor.) Our account appears to be strictly logical; it jettisons ambiguous colloquial speech, carries no social scent, and is narrated in a strictly neutral or impersonal voice.

The reasoning Darwin requires of his reader is more subtle, nuanced, insinuative, and complex than our version requires. A reflective reader of Darwin's language is asked to hold in tension (or resolve himself) two opposed logics: an algorithmic logic that would subsume all adaptation and all divergence from type under Malthus's laws of population and a prudential logic that consistently suggests that behind the seeming common sense absurdity and theological novelty of Darwin's first logic is a larger teleology.[6] The first logic is relentlessly reductionist and materialist. The second logic

relentlessly uses conventional phrases and diction to suggest the religious and metaphysical perspective the first seems to deny. The crux of the difference between the materialist and the spiritualist logics of the passage, and the way Darwin prudentially avoided a showdown between them, emerge most clearly in his metaphor "natural selection."

From one perspective, natural selection is merely a metaphor. In a later edition, Darwin himself underscored the figural character of natural selection when he prefaced his personification with "it may metaphorically be said."[7] Following this interpretation, one might say that the cognitive status of Darwin's term was comparable to that of the geometrical terms "point" and "line," which suggest images, but themselves are imageless concepts. Yet the subtlety of natural selection as a concept and the cognitive work performed by its religious overtones make untenable any minimizing of the importance of the figure. The social and theological ring of Darwin's language is not merely decorative or ameliorative, but is constitutive of the fabric of his thought. Darwin did not say that natural selection is the opposite of the religious view that species are produced miraculously. He did not baldly state that natural selection means merely that certain animals with certain traits die and others with other traits live, that the process is so random it might with propriety be called "natural sifting." What he did say is that nature is like a breeder, only infinitely more powerful; that nature's adaptations are far "truer" than ours; and that the power and the art of natural selection should remind us of how small we are in the great scheme of things. If the theological color of "natural selection" were not obvious enough, it is enhanced by Darwin's figure "the hand of time," which is a personification within a personification. Darwin's figure of time's "hand" can be read as an extension of the breeder's hand, of nature's hand, or of God's hand. Any one of these interpretations or any combination could not be ruled out by even a careful interrogation of the text, nor would the ambiguity be lessened were the context expanded to include the whole chapter or the whole book.[8]

Darwin's theological language opens to our view an entire dimension of his reasoning — indeed of his project as a whole — which our definition of his theory ignores. In removing every vestige of Darwin's diction, our version of natural selection treats Darwin's theory as if it were an algorithm, as though the richness of his insight could be reduced without essential loss. The danger in setting aside Darwin's language is that we effectively remove half of the problem he addressed and disregard the intelligence required to address it — how to present a radical idea to a particular scientific and popular audience in a way that retains the persuasive force of the very tradition it destroys.

Not only in the robust language of the *Origin*, but also in the minute and diverse reflections in his notebooks on "transmutation" (as evolution was then known), Darwin has left us a detailed record of how he thought about nature, species change, and the probable response of his audience to the various formulations of his theory. Despite some omissions and lost sheets, we have all five of his transmutation notebooks. We have Darwin's 1842 sketch and 1844 essay on his theory of natural selection, and we have the big species book "Natural Selection," which Darwin abandoned in 1858 to write his more compact *Origin of Species*. Thanks to the work of Smith, Herbert, Kohn, Ospovat, Sulloway, Hodge, and Sloane, we have as clear an idea as probably we ever will of the stages of Darwin's thought.

I would like to offer a positive way of examining the reasoning which led Darwin to the theory of natural selection and to his epochal book, *On the Origin of Species*. What

makes Darwin's logic rhetorical and specifically inventional is his sense of tradition, stasis, timing, and the appropriate. Tradition is central to understanding Darwin's logic for, iconoclastic as Darwin's revolution was, his inheritance from others — especially his initial inheritance from Charles Lyell — was a major inventional resource out of which he fashioned his innovations. Stasis illuminates Darwin's rhetorical logic, for what Darwin did with his tradition — and whether he merely repeated it or changed it — depended on the specific questions he was asking. Timing similarly helps explain Darwin's reasoning, for the extent to which Darwin on the voyage repeated or questioned his tradition depended in part on his physical location, whether he was viewing something for the first time or reconsidering it in retrospect, and after his return, on the prior theories he had developed. A sense of the appropriate is inherent in all of the above, for one of the distinguishing marks of Darwin's genius is his ability to see, or rather to seize the similar in the different and thereby draw unexpected conclusions from conventional premises.

While one can identify key turning points in Darwin's thought, such as his initial belief in some form of transmutation, or, well after his return, his reading of Malthus, Darwin represents the extreme antithesis of the Archimedean model of scientific insight, in which a single insight reveals the whole of some seminal idea. There is no one moment in which Darwin was gifted with the whole of his mature thought. By loose analogy with the contemporary theory of "punctuated equilibrium," we can say that sometimes Darwin's thought remained markedly constant with but slight variations, but then — as in the final months of the *Beagle* voyage, or immediately on his reading of Malthus — it shifted abruptly. The task of the following rhetorical analysis will be to keep these moments of sameness and difference in balance while keeping them all in play and show how — whether in its more active or in its more passive modes, in its "discovery" as in its "justificational" stages — the logic of Darwin's thought drew upon its own past and upon immediate circumstances to frame for each of its occasions a fitting strategic and stylized response.

The logic of our story, at least initially, will require some chronological weaving back and forth. Because of its prominence in popular Darwinian myth, it is useful to begin in September and October of 1835, approximately four-fifths of the way through the *Beagle* voyage, during Darwin's five-week stay in the Galapagos, when he was at the unabashed height of his creationism yet paradoxically surrounded by evidence for evolution. From there we will move forward 8 months to Darwin's first recorded glimmering of species mutability, and then backward 24 months to discover the inventional resources within the specific tradition of creationism that made it possible for him to think the hitherto unthinkable.

Darwin's Conversion to Transmutation

It is inconceivable that the *Origin* could be the kind of document it is had not Darwin's language and thought been steeped in the diction and argumentative conventions he would overthrow. Yet to emphasize Darwin's heavy reliance on convention makes his originality seem to be a paradox wrapped in a dilemma. If thought is bound by language and language is the language of convention, how could anyone, including even a genius like Darwin, ever break free? It is almost as though we have to import a version of special creationism into intellectual history to explain how the biological theory of special creationism was overthrown!

Fortunately, the "dilemma" between linguistic determinism and the fact of conceptual innovation is largely a product of an inadequate view of language and of reason, particularly of rhetorical reason. As our formalistic version of Darwin's theory shows, the dilemma rests on disregarding as unreasonable the humble guise in which reason comes to us in daily life. If, however, we claim as reasonable the "impure" language we see in Darwin's *Origin* (whatever its edition), we can also understand the quality of thought that led to it. Not that we can use the *Origin* to postdict the stages of Darwin's project — Darwin covered his tracks too carefully for that — but that the language of his notebooks, while lacking some of the concepts and most of the polish of his finished composition, reveals a man working in a world characterized by the same metaphoric and theological features we find in his finished work.[10] To resolve the seeming paradox of how Darwin's creationism is implicated in the logic that led him to evolution, we must first understand how the strategic and stylistic resources of Darwin's initial tradition prepared him to see what convention determined he see; and how later, fresh experience, further reflection, and a sense of opportunity placed the linguistic and strategic resources of his traditions in a new light, enabling him to invent first one and then many logics of evolution.

From Creationism to Darwin's First Evolutionary Insight

When Darwin was on the Galapagos Islands and surrounded by what later he realized was some of the most important evidence of evolution, he thought and collected specimens as a convinced creationist. The Galapagos finches, for example, until recently were advanced as part of the evidence that presumably convinced Darwin of the truth of transmutation. Yet, as Sulloway has shown, Darwin personally collected only a very few specimens and did not bother even to record the island from which they came. (Why collect many if God created but a few original types, and when the local birds so clearly were variants of the South American ones?) Only on his return to England, when specialists helped him to appreciate the value of this evidence, did he borrow the carefully labeled collections of his shipmates from the voyage. Unfortunately for ornithologists, he guessed at the locations for his own birds, mixed them with the locations given by the sailors, and created a taxonomic nightmare at the British Museum. Only recently has Sulloway been able to rebut the thesis that there has been evolution on the Galapagos since Darwin's time by showing that the appearance of change resulted from the fact that Darwin put birds on the wrong islands to begin with.[11]

A similar illustration of how thoroughly Darwin's first view of the Galapagos was filtered through the lenses of creationism is given by the Galapagos tortoises. According to the traditional classification of the tortoises as *Testudio indicus*, the tortoises had been transported to the islands from the West Indies. Though Darwin had been told by the vice governor of the islands, Nicholas O. Lawson, that the tortoises were so distinct that he could tell from which island any particular one came, the fact of mere variability in these supposed colonists did not seem to him scientifically important at the time.[12] He would labor over the next 10 years to reconstruct from secondary sources proof of species development he had let slip by.

Indisputably important as was Darwin's early creationism, the resources of reasoning in which it was embedded were far richer than Darwin's initial view of the Galapagos would suggest. Before the voyage was over, Darwin made a second "visit" to the Galapagos, this time not in person, but reflectively as he looked back over his notes

and specimens. In Darwin's second look at the Galapagos, the point at issue in his investigation had dramatically changed, allowing explanatory resources latent in his creationist framework to be rearranged and to open new avenues of inquiry.

Darwin's first note questioning the fixity of species was written between June and July of 1836 — scarcely nine months after his visit to the Galapagos Islands — as the *Beagle*, having rounded the horn of Africa, was heading toward England. Darwin was in the process of putting his Galapagos collections in order and, in light of the imminent end of the voyage and his own growing confidence in himself as a seasoned naturalist, naturally had an eye out for potentially significant generalizations. Reflecting back on the islands especially in light of his collection of mockingbirds, Darwin observed:

> The specimens from Chatham and Albermale [sic] Isd appear to be the same; but the other two are different. In each isld. each kind is *exclusively* found: habits of all are indistinguishable. When I recollect, the fact that from the form of the body, shape of scales & general size, the Spaniards can at once pronounce, from which Island any Tortoise may have been brought. When I see these Islands in sight of each other, & possessed of but a scanty stock of animals, tenanted by these birds, but slightly differing in structure & filling the same place in Nature, I must suspect they are only varieties. The only fact of a similar kind of which I am aware, is the constant asserted difference — between the wolf-like Fox of East & West Falkland Islds. — If there is the slightest foundation for these remarks the zoology of Archipelagos — will be well worth examining; for such facts [would inserted] undermine the stability of Species.[13]

While the meaning of this note is disputed among Darwin scholars — is he saying he believes in evolution, or only considering it? — the note is important, for it establishes Darwin's awareness of a timely and radical opening in the fabric of convention. Even if we agree with Sulloway that here Darwin is only considering the possibility of transmutation to set it aside for want of evidence, why he would regard transmutation as an attractive explanation at all, let alone in such a calm and matter-of-fact manner, indicates his received explanatory framework was in flux.[14]

Darwin was, of course, no stranger to the doctrine of evolution when he began his voyage. His grandfather had won fame and later notoriety through his popularization of an early theory of evolution, and Darwin's teacher at Edinburgh, Robert Grant, had expressed high praise for the theories of Lamarck. Evolutionism and the materialism with which it was associated were frowned upon by respectable science, especially by the science favored by the church and by the Cambridge teachers with whom Darwin was most closely associated, Adam Sedgwick and John Stephens Henslow.[15]

As Hodge has pointed out, Darwin began his voyage as a follower of the "catastrophic" geological theories of DeBeaumont and of his own teacher Adam Sedgwick. According to DeBeaumont and Sedgwick, the Andes were relatively young and had been produced in one or two gigantic upheavals by geological forces not then observable. These same forces had caused an enormous tidal wave recorded in the flood legends of various peoples — including the flood story of the Bible — that had caused the destruction of numerous plants and animals and opened the way for the creation of the many new species that appeared in its aftermath. It is easy to see how, had Darwin continued to see the world of geology and biology through the lenses of these theories, he would have seen the Galapagos as confirming a creationist view of species. What is not easy to see, however, is what could ever have loosened the grip of

such a strong version of creationism long enough to tempt Darwin to write his quasi-evolutionist note.[16]

Darwin's note, recorded in his *Ornithological Notebooks*, represents a shift in the stasis of the questions guiding his research that takes its meaning from a prior change in the explanatory framework of his creationism. The explanatory framework of Darwin's second creationist perspective, and Darwin's discovery of specific anomalies within it, place in relief the inventional logic that generated Darwin's first glimpse of evolution and the germ of his subsequent theories.

In April 1834, after his visit to the Santa Cruz valley, Darwin abandoned the catastrophic view of geology he had learned as an undergraduate and explained the geography of the region as being due to numerous small upheavals that had raised gradually both the Andes and the surrounding plains, and that had produced a number of extinctions (as opposed to one or two big ones) and numerous introductions of species. The source of Darwin's new explanations was Charles Lyell's *Principles of Geology*. There is little to match the concentrated attention of a talented student when he discovers the mistakes of his first teachers! In one sense, in accepting Lyell's geological program, Darwin merely went from creationism to creationism for, every bit as much as had DeBeaumont and Sedgwick, Lyell too affirmed that species had been specially and miraculously created. But if Lyell was conventional in his view of the means of species origins, his rich explanatory legacy to Darwin was his unconventional account of their distribution and of the timing and "logic" of their introductions.

As its full title indicates — *Principles of Geology, Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation* — Lyell wished to give his version of geology the aura of system and scientific certainty characteristic of Newton's *Principia*. Lyell's actualism — his insistence on making presently observable causes the test of all real science — was a polemical stick by which he sought to associate all opposition with the traditional enemies of science: myth and superstition. The core of Lyell's project was to develop a theory of geology grounded on Hutton's 1785 *Theory of the Earth*. Hutton was an extreme antiprogressionist and had argued for a steady-state world designed to ensure forever the habitability — though not the specific habitations — of all the plants and animals God had created at the first. According to Hutton, igneous forces built up the land and aqueous forces wore it down. The earth's crust was going nowhere in particular and offered "no sign of a beginning, no prospect of an end."[17]

What made Hutton seem antiquated to all of Lyell's colleagues was the clear evidence of floral and faunal succession uncovered by stratigraphy since Hutton's time. Lyell boldly coupled his Huttonian geologic actualism with the evidence of biogeography to show how the earth was designed to be habitable, if not always for any given aboriginal species of plants and animals, at least then for the major groups of life forms, from lichens to ferns to mammals. In combining a neo-Huttonian program for explaining the dynamic changes on the surface of the earth with the data of extant and extinct floral and faunal distribution, Lyell sought to make geology, geography, and biology different facets of a single unified science.[18]

Lyell's actualism was far from abstract. His rhetorical long suit was *hypotyposis*, or *pragmatographia* — so describing an event that it seemed to unfold before the reader's eyes. Lyell's figure was well suited to its function, for his theory required that he impress the reader with the adequacy of existing forces to accomplish immense changes over time (or to reverse any given apparent direction over time) even though no one ever actually witnessed the end these forces achieved — a species

going extinct or coming into being. Rhetorically, and this would later be an important part of his legacy to Darwin, Lyell had to create such a presumption in favor of the inexorable power of existing forces that the line in the reader's mind between what he actually could see and what he technically could not became blurred and merely academic.

Lyell's use of the figure *hypotyposis* to lend what Perelman would call "presence" to his case was buttressed by his use of two additional explanatory strategies.[19] In the first, he would point to processes currently in operation — for example, the loss of a particular animal or plant or habitat — and then would note in the rocks evidence of species extinction. He would then bridge the gap between the observed and the not-observed by arguing that while we do not observe the actual extinction of a particular plant or animal, we do witness the forces that destroy its habitat and make it rare, and we do witness via the geologic record that species extinctions occur. The connection between the seen process and the unseen eventual effect seemed inevitable. Though Lyell himself was none too pleased with it, his second strategy — his attempt to historicize if not naturalize the origin of species — was an immediate corollary of his first strategy. Here Lyell began with the facts of present geographical distribution and of the geological succession of flora and fauna to show that even as habitats and ranges are coming into being and passing away, so from time to time various kinds of plants and animals have been created to inhabit them. As the geologic record plainly tells us that the emergence of new species is a fact, and while we observe it no more than we observe extinctions, we must assume that the origin of species is still going on as part of the same system of natural laws that governs the rest of the terrestrial system. Lyell sought to strengthen his case further by arguing that so much of the earth lies beyond the immediate observation of Europeans and so infrequently would new species emerge that is was hardly remarkable that Europeans had not yet witnessed a species origin.[20]

Important as was this last point for Lyell's view of geology as a science, it created, as should be apparent, an enormous rhetorical asymmetry in his case. While Lyell had exquisitely prepared the reader to imagine what he or she would see in witnessing an extinction, the reader — other than perhaps being half-convinced that species origins were ongoing events — would not have had the faintest hint as to what to expect at a species origin.

It is here that Lyell, by the cunning of a Hegelian reason, put at Darwin's disposal resources that allowed him to use Lyell's very categories to undermine Lyell's conclusions. Darwin's shift from the catastrophic creationism of DeBeaumont and Sedgwick to the actualist creationism of Lyell is one of the single most important shifts of his career, second only to his acceptance of evolution or perhaps to his later formulation of natural selection. And yet the change must be placed in proper context. Darwin's acceptance of Lyell was not a catastrophic shift to a new paradigm, but a major restructuring of a common creationist framework.

The place and time of Darwin's conversion to Lyell's geology helps us to understand both why he reacted initially to the Galapagos Islands the way he did, and why, eight months later, he saw them so differently. The place of Darwin's conversion to Lyell's program was southeastern South America, roughly from Buenos Aires in the north to Port St. Julian in Patagonia to the south. Its timing, approximately four-fifths of the way through the *Beagle* voyage, tells us that Darwin's acceptance of Lyell was based on his extensive study of the South American continent, later including the west coast and the Andes, and it was his experience of oceanic islands that eventually led him to

question Lyell's view of species origins and accept transmutation.[21]

With its abundant evidence of numerous small but periodical upliftings, southeastern South America seemed to Darwin clearly to support both Lyell's actualist or uniformitarian geology and to confirm his view of the introduction of new species. Lyell taught that if a region was short on species, both indigenous and otherwise, the land would be recent and inaccessible. By contrast, a region that was short only of indigenous species would be recent but accessible. Lyell's favorite example of the power of geology to explain otherwise puzzling facts of biogeography was Sicily. To most observers Sicily seemed to have less than its share of indigenous species. But Lyell (triumphantly) rejoined that this was because "three-fourths of the isle were covered by the sea down to the period when nine-tenths of the present species of shells and corals (and by inference plants) were already in existence."

In his geological notes Darwin used Lyell's Sicilian precedent to explain the dearth of animals along the Patagonian coast. At Valparaiso Darwin noted that despite the abundance of bushes, there were few insects and also few "higher orders" of animals such as quadrupeds or birds. The beds of extant shells, with their colors hardly diminished, proved the recent elevation of the land. Given that the land was new, impoverished of fauna, and inaccessible, Darwin, repeating the creationist language of Lyell, observed that it seemed "not a very improbable conjecture that the want of animals may be owing to none having been created since this country was raised from the sea."[22]

Darwin did not follow Lyell uncritically, enthusiastic as he was about his general perspective. According to Lyell, species became extinct because gradual, incremental changes abolished their environments. Yet as Darwin struggled in January 1834 at Port St. Julian to make out the succession of the extinct and extant plant and animal species along the coast of Patagonia, it did not seem to be the case that the mastodon whose bones he discovered had inhabited an environment materially different from the present one. What had been unclear to Darwin in January 1834 in Patagonia gradually became clear to him in February 1835, most likely when he was sailing between Chile and Valdavia on the Pacific.[23] While the passage in which he wrote out his views is too long and involved to cite in full, the following excerpt captures the central element of his reasoning.

> The following analogy I am aware is a false one; but when I consider the enormous extension of life of an *individual* plant seen in grafting of an Apple tree & that all these thousand trees are subject to the duration of life which one bud contained. I cannot see much difficulty in believing a similar duration might be propagated with true generation — if the existence of species is allowed, each according to its kind, we must suppose deaths to follow at different epochs, & then successive births must repeople the globe or the number of its inhabitants has varied exceedingly at different periods. — A supposition in contradiction to the fitness which the Author of Nature has now established.[24]

Though some of the reasoning in this passage is complex and draws on a non-Lyellian strand of Darwin's work that we will examine more closely when we come to Darwin's notebooks, the analogy that grounds it is easy to understand. Darwin rejected Lyell's environmentally determined account of extinction and was pursuing a biological analogy between the limit to the duration of the individual life and the limit to the duration of species. In his South American travels Darwin had seen the remains of whole orchards that had been generated by grafting and had long been productive,

but whose trees had all died at the same time. Darwin was claiming in this passage that even as artificial grafting can transmit a limit to the life of the individual plant or animal, and thus to all the individuals generated by graftings from it, so also might a limit to the duration of life be passed on through sexual generation.[25]

With tentative and apologetic language, Darwin drew on these observations to replace the traditional contrast between the artificial process of grafting and the natural process of sexual generation with an analogy between them. In breaking with Lyell on species extinctions, Darwin did not deviate from Lyell's broader explanatory paradigm. Lyell himself had called attention to the suggestion of Giovanni Brocchi that there might be a genetically imposed limit to the duration of species, as there was to the life span of individuals. While Lyell unequivocally rejected Brocchi's view as unsupported by evidence, he accorded it status by recognizing it as a potential alternative to his own. As evidenced by his phrase "each according to its kind," Darwin continued to speak the very language of Genesis. In his final comment — "Successive births must repeople the globe or the number of its inhabitants has varied exceedingly at different periods. — A supposition in contradiction to the fitness which the Author of Nature has now established" — Darwin reaffirmed with Lyell that species extinctions are followed by special creations to maintain the divinely instituted order of the world.

Darwin initially saw the Galapagos just as he had seen the Andes — as a further extension of the Lyellian geology he had accepted in southeastern South America. We do not see Darwin on the Galapagos, no more than when he was in the Andes, attempting to extend his critique of Lyell's views on extinction to species origins, nor do Darwin's notes show any trace of an attempt to explain why the islands had the species that they had or why they lacked the ones they lacked. Yet within a year these very questions would be at the forefront of his thinking. What stirred Darwin to rethink his commitment to Lyell's explanatory program was a timely change of venue — Tahiti, New Zealand, Australia — and the surprise of flora and fauna stranger than any he had ever seen.[26]

While Darwin had found Tahiti of geological interest, and joined with Fitzroy in writing in support of the work of Anglican missionaries there, he found little in it of botanical or zoological interest. New Zealand, the *Beagle*'s next port of call, was a different matter. Here was a very large island with varied and contrasting "stations" capable of supporting abundant life. Yet, in the thick woods Darwin discovered there were few birds, and in the whole island there was only one indigenous animal, a native rat, and it was being exterminated by the European rat introduced but two years before. A similar fate was overtaking the native plants. Lyell had accounted for New Zealand and Australia by offering them as illustrations of the expected lack of mammals during his secondary age of northern archipelagoes. Perhaps it was the sheer size of the land involved, but "adaptation" to conditions no longer seemed to Darwin a credible explanation for what was missing, particularly in land that was not geologically young.[27]

Though we have no unambiguous textual evidence that Darwin became convinced of transmutation on the voyage, in Australia his thinking seems to have reached a crossroads. A revealing, if subtle, text appears in Darwin's *Beagle* diary and, in a slightly altered form, in his published *Journal of Researches*. While lying on a sunny bank, Darwin reflected on a passage from Lyell that supported Paley's affirmation that, despite the diversity of his works, there is but one creator. Darwin mused "on the strange character of the animals of this country as compared to the rest of the World,"

and, building on Paley and Lyell, imagined a dialogue between a "Geologist" and a "disbeliever." To the disbeliever relying on reason alone, Australia would seem to prove that, even though each would have aimed at fully stocking his respective territory, two distinct creators must have been at work. But spotting a lion-ant which, though specifically distinct from the European form, had the same predatory habits of its family, Darwin seemed to find what he needed to rebut the skeptic. In the 1839 edition of the *Journal*, Darwin observed: "Now what would the sceptic say to this? Would any two workmen ever hit upon so beautiful, so simple, and yet so artificial a contrivance? It cannot be thought so: one Hand has surely worked throughout the universe." In the diary, however, there is a further and potentially revealing sentence. The sentence reads, "A Geologist perhaps would suggest that the periods of Creation have been distinct and remote the one from the other; that the Creator rested from his labor."[28]

The final sentence is of particular interest because while the first indicates acquiescence in conventional creationism, the second suggests that, though the creator may be one, when he came to Australia he seems — perhaps like Darwin himself — to have paused and then redrafted his plans. Noticeably absent from Darwin's notes is any invocation of Lyell's "Sicilian precedent" example. In neither New Zealand nor Australia could the species — present or absent — be accounted for by the youth of the land or on the basis of adaptation. Why no animals of any kind in New Zealand, seeing its perfect fitness for them; and why only marsupials in Australia, seeing how well mammals did when introduced?

In the wake of his growing awareness of the failure of Lyell's account of species origins, it is highly probable, and circumstantial evidence strongly suggests, that Darwin followed the same course of invention as he had earlier when he broke with Lyell's account of extinctions: he picked up the alternative theory Lyell had rejected — evolution.[29] The strongest circumstantial evidence that Darwin accepted evolution on the voyage are the notes Darwin took on the west coast of South America, which contain the passage cited earlier questioning the fixity of species.

According to Lyell, a scientific natural history of a region required the integration of four elements: conditions, geologic history, adaptation, and differential migration.[30] As had been true in his first Galapagos field notes, which contain the proto-evolutionary passage cited earlier, so in his revised version of them, Darwin reviewed the volcanic character of the islands; their arid climate; the leafless, stunted brushwood near the coast; and the contrasting luxuriant woodlands 1,000 to 2,000 feet higher. But when he came to the woodlands on the windward side of the islands, the dense vegetation of which was nourished by the abundant rain, Darwin's reflections took a critical turn. Darwin noted that in such a spot he had expected to find swarms of insects, but in fact found very few and was surprised further to find the woods "scarcely tenanted by a single animal."[31] Then, rather than following the explanatory narrative he himself had used in writing his account of southeastern South America — Lyell's Sicilian precedent, which held one would not expect new species on new land — Darwin implicitly played Lyell's categories off against one another.

When applied against the insects, Lyell's test of "conditions" failed, even as it had failed earlier and even more spectacularly in the case of the European rat exterminating the native New Zealand and Australian rats. Clearly if the "conditions" determined the life forms, then there would have been an abundance of insects, not only in numbers but in whole supraspecific classes. Darwin accounted for the presence of numerous finches and the paucity of other supraspecific groups of birds — warblers — by a

combination of conditions and migratory powers. There were no warblers or other insectivorous birds because, even if they could have reached the islands, there were too few insects to sustain them. The presence and numbers of the finches could have been explained by the numerous seeds left in the sandy soil by the scrub brush that blossomed briefly following the brief rainy season. Subtle though the point is to grasp at first, as Hodge points out, the unstated assumption behind Darwin's reasoning was that the finches were explained partly by conditions, partly by migration, and partly by inheritance from their ancestors. In the new stress Darwin was placing on inheritance, we see his implicit assumption of evolution.[52]

While the proof that Darwin became convinced of evolution on the voyage is not decisive, the negative evidence of Darwin's abandonment of the Lyellian explanations he had used earlier in southeastern South America, plus the positive evidence of Darwin's use of Lyell's categories in novel ways, added to the continuity between his final speculations on the voyage recorded in his *Ornithological Notebooks* and his first unequivocal evolutionary speculations, are very persuasive. Whenever Darwin converted to evolution exactly, Hodge makes an excellent point when he observes that Darwin first became a transmutationist when, as a Lyellian geologist, he recognized that transmutation had to be added to Lyell's other criteria for his biogeography to make sense.[53]

Darwin's Return and the Inventional Context of His First Theories

Darwin's return from the *Beagle* voyage marked an important new stage in his thought — not, as I argued elsewhere, because it was the beginning of his inventional program, but because it was the point at which he decided to make pursuing it the focus of his career.[54] Starting with his careful arrangement for the placing of his South American collections in the hands of the most highly qualified of his contemporaries — John Gould agreed to describe his birds and Richard Owens his extinct mammals — Darwin quickly established himself upon his return as a rising young star of British science. While preparing his *Journal of Researches* for publication, Darwin moved to London, became a member of the Geological and Zoological societies, presented papers at meetings, and eventually became permanent secretary of the Geological Society. In June 1837 Darwin sent to the printer his *Journal of Researches* — initially the third volume of the official report of the voyage of *HMS Beagle* and later published independently as a commercially successful book. By the end of July he began his "B" notebook, the first of his formal notebooks of transmutation, and in the opening several pages took the key strategic decisions that would form the context of his theorizing up to and even beyond his rereading of Malthus and his development of the theory of natural selection in 1839.[55]

The coincidence between the period in which Darwin began to be most active and visible on the London scientific scene — before his marriage in 1839 and his subsequent semiretirement to the countryside in 1842 — and the decisive period in the development of his evolutionary speculations confronted him from the first with the prudential necessity of concealing his new views. For Darwin to have been associated in these years with a materialist theory that was dubious science and irreligious to boot would have been professional suicide. That Darwin's first positive formulation of his theory occurred while he was writing Chapter 9 of his *Journal of Researches* marked the *Journal* as the work in which the calculated ambiguity so characteristic of the language of Darwin's *Origin* first emerged.

Darwin's *Journal of Researches* was stylistically modeled after Alexander von Humboldt's *Personal Narrative*. The *Journal* was based on Darwin's own diary, interleaved with selections from his technical notebooks on zoology, biology, and coral reefs.[46] Chapter 9 described the biogeography of southeastern South America, where Darwin first accepted Lyell's geologic program and later broke with his environment-based views of species extinction. In the course of writing this chapter (almost certainly in March 1837), Darwin entered, in the remaining pages of his *Red Notebook* (later known as "RN"), a sketch of transmutation that linked species senescence with species origins. In the published *Journal*, most of Darwin's premises appear, but not his evolutionary conclusions. The language of "centers of creation" and "laws of creation" that we find throughout the work and his rebuttal to the thesis that Australian fauna argue for two creators that we examined earlier must be seen as consciously ironic — Darwin's first rhetorical response to the prudential challenge of establishing his reputation while giving nothing away on his heretical view of species.

We must be careful, however, not to press too far the distinction between the form of Darwin's language and the substance of his thought. The inventional dimension of Darwin's thought goes much deeper than Darwin's conscious use of misleading diction. As we examine the genesis and early development of Darwin's ideas, we find that form and content, what Darwin wanted to say, the social and linguistic resources available to him for saying it, and the audience he wished to say it to are constitutive of his logic.

The Theory of Darwin's "RN" Notebook

Darwin's first evolutionary observation began with his noting Gould's classifying as distinct species two ostriches Darwin had brought back from Patagonia. The larger and more northerly ostrich, the Orpheus, was well known, but the Petise, or smaller, southern ostrich, was new to European science. Darwin then connected and contrasted the manner of the origin of these two ostriches with his earlier observations from the voyage on the relation between the flora and fauna of neighboring continents and oceanic islands: "Speculate on neutral ground of the two ostriches, bigger one encroached on smaller." In the absence of any intermediate forms between the two, whose territory overlapped at one point, he drew a radical if obvious conclusion: " — change not progressif(e): produced at one blow."[47] The sudden form of transmutation Darwin saw evidenced by the ostriches he contrasted with the gradual transmutation he found indicated in the relation of the flora and fauna of oceanic islands to continents:

> My idea of Voc: islands elevated then peculiar plants created. if from such mere points; then any mountain, one is falsely less surprised at new creation for large. — Australia. = if for volc. isld then for any spot of land. = Yet new creation affected by halo of neighboring continent (RN 127)

Here Darwin stated explicitly the reasoning we traced (following Hodge) to his notes from late in the voyage. Darwin reasoned that if oceanic islands are stocked by migration and subsequent divergence of offspring from their parental stock, then a similar naturalistic explanation — based on migration and inheritance — must hold for continents. Reasoning topically from "lesser to greater," Darwin confronted Lyell's heavy reliance on "adaptation to conditions" at its weakest point and claimed that whatever holds for oceanic islands ("mere points") applies equally to larger masses of land

("any mountain") or even a continent ("Australia"). We must also note the ironic turn in the final entry of this passage. If no naturalistic relation connects the flora and fauna of islands and continents, then the similarities must result from a "halo effect" — a sort of holy fallout — from a continental miracle. By turning Lyell's biogeographic mode of explanation back on itself, Darwin was able to create out of prior convention the beginning of an alternative framework of expectations. Out of the wreckage of Lyell's quasi-supernatural syntax, Darwin was consciously creating an alternative grammar of science.

Having developed two positive images of transmutation — a theory of evolutionary leaps for continents and a gradualistic model of divergence from ancestors following an initial migration for islands — Darwin returned to continents and refined his saltationist theory. Darwin integrated Gould's classification of the two ostriches as distinct with similar findings from Owen. Owen had determined that a large, extinct Patagonian mammal, the bones of which Darwin exhumed and which Owen christened "macrauchenia," was a camel and thus of the same family as the living South American camel, the llama. Owen's finding thus confirmed Lyell's "law of the succession of type" — that like families succeed one another over a period of time in the same territory. Arguing from a parallel case, Darwin affirmed that the geographic succession of species of the same family one observes in traveling in space from northern to southern South America is a sign of the transmutation of species over geologic time.

> The same kind of relation that the common ostrich bears to (Petisse....); extinct [macrauchenia] to recent [Llama]: in former case position, in latter time." (RN 130) Since both examples show an absence of intermediate forms, the evidence from both present and past seems to agree. "As in first cases...so must we believe ancient ones: not *gradual* change or degeneration, from circumstances: if one species does change into another it must be per saltum — or species may perish." (RN 130)

With leaps established as consistent with the taxonomic and biogeographic data, Darwin shifted his argument from specific examples to the biological principle underlying them:

> Propagation, whether ordinary, hermaphrodite, or by cutting an animal in two, (gemmiparous, by nature or accident), we see an individual divided either at one moment or through the lapse of ages. (RN 132)

By moving from the concrete to the abstract — from his concrete examples to "propagation," the biological principle that their emergence presupposes, Darwin arrived at a topos that enabled him to generate a new series of images through which to envision the evolutionary process as a whole. These images — "ordinary, hermaphrodite, or by cutting an animal in two" — allowed Darwin to move from large to small animals and between sudden and gradual modes of reproduction. Again, as in his survey of geographic evidence, Darwin was concerned equally with the facts and the psychology of belief. His last line — "we see an individual divided either at one moment or through the lapse of ages" indicated his desire to downplay the precise mechanism and to insist that whatever it is exactly, it is ordinary and unsurprising.

Following his generation of new images for the evolutionary process, and parallel to his earlier defense of evolution by leaps, Darwin then instantiated his more encompassing principle of propagation in a concrete example using a microscopic animal — the zoophyte: "Therefore we are not so much surprised at seeing Zoophite producing

distinct animals. still partly united. & eggs which become quite separate." (RN 132) In this example Darwin used the zoophyte as metaphor. The zoophyte has some of the features of a plant and some of an animal and poses the same problems as would a plant for distinguishing between the individual and the community. Because of the ambiguities surrounding just how the zoophyte reproduces (Darwin studied zoophyte reproduction at Edinburgh and throughout the *Beagle* voyage), it served him well as a paradigm for his revised image of evolution as a whole.[58] The zoophyte paradigm allowed Darwin to equalize all forms of life, animal and vegetable; all forms of reproduction, sexual and asexual; both forms of transmutation, sudden and gradual; and to combine the individual and the group into a single entity that embodies life, death, division, and continuity over time. Indeed, the image shows the contribution to creative thought of positive, if confused, rhetorical images — images that do not so much delineate a specific concept as bring strikingly before the mind a range of explanatory possibilities.

> " — Considering all individuals of all species as [each] one individual [divided] by different methods, associated life only adds one other method where the division is not perfect. — " (RN 132)

As Kohn has noted, Darwin's first theory had transient and permanent features. The mechanism of leaps was transient. As an explanation of evolution, leaps could not be sustained theoretically, for Darwin soon learned that the closest known parallel to them — what domestic breeders called "sports" or "monsters" — were usually short-lived. Darwin's insight that the mechanism of evolution would turn out to be some aspect of reproduction was permanent and would be the basis of each of his subsequent theories.[59]

From Sexual Generation to Natural Selection

Following his conversion to evolution, Darwin's theorizing followed two main types (each with significant variants of its own): his theory of sexual generation and his theory of natural selection. As elsewhere I have described the development of these theories, here I will but characterize each type, summarize the inventional logic that led Darwin from the first to the second, and relate them to the earliest phases of Darwin's thought.[60]

Darwin's Theory of Sexual Generation

Darwin's second theory of transmutation was introduced in notebook "B" of what has come to be called his "Transmutation Notebooks" and was opened in July 1837. The main tenet of this theory was that sexually generated variants are the engine of evolution. According to this theory, Huttonian/Lyellian processes act directly on the reproductive systems of plants and animals. As a result of these environmentally induced reproductive changes, the next generation of plants and animals is born with variations that adapt them to their new environment. The biological caveat in this theory is that organisms are adapted to their new environment as far as the previous history of their adaptations allows them to be. Organisms that are unable to change fast enough will become extinct. In effect the theory subsumes Lyellian special creationism into a biological actualism. Rather than holding "creation" to be an unknown law, Darwin saw creation occurring incrementally through providentially guided variations operat-

ing in each generation as a biological response to environmentally induced change. The visual element which Lyell's "law of creation" left blank, Darwin here filled in.

Three brief comments will clarify this theory before we turn to its principal variants. First, unlike Darwin's first theory that equated asexual and sexual modes of reproduction, Darwin's sexual generation theory sharply distinguished them. Darwin took the distinction between sexual and asexual generation from his grandfather Erasmus Darwin, who pointed it out in his medical encyclopedia and evolutionary apology *Zoonomia*, the title of which adorns notebook "B." Second, contrary to his earlier theory of leaps for evolution on continents and gradual changes for evolution on oceanic islands, Darwin's new theory explained how both island and continental evolution primarily result from gradual, quasi-random yet implicitly divinely directed biological changes. The speed of evolution on Darwin's generation theory is relative, for while change occurs over generations rather than at once in sudden leaps, in a rapidly changing environment it would occur more quickly, while in a more stable one it would be much slower. The variable speed of evolution was a rhetorical advantage to Darwin, for it left him free to develop different case histories differently. Darwin's theory was quasi-random, for it tied biological change to geologic change, which Hutton and Lyell had shown are not directional. Yet evolution, as Darwin explained it, is teleological, for the variations that result from sexual generation are not purely random but are automatically adaptive. Third, though Darwin's theory operated through small gradations, it did not anticipate logically his mature theory of natural selection, for his speculation was built on an opposition between nature and domestic breeding rather than on an analogy between them.[7]

In the course of his notebooks Darwin introduced two variants to his theory of sexual selection. While each of these variants was scientific in that each was addressed to specific questions, each was also "inventional" in that, to be persuasive, Darwin had to subsume the range of biological thought of his time within his evolutionary synthesis. The first variant in Darwin's sexual generation theory was microbiological. Darwin drew upon contemporary German microbiological thought to show how contemporary theories of the micro development of the germ were compatible with his macro view of evolution as a result of the interaction between the organism and the changing environment. In viewing life as analogous to a chemical reaction — as a way in which matter behaves under certain configurations — and individual development as a result of the irritability of the germ in relation to its situation rather than as the result of a preformed program, contemporary German vitalist materialism seemed to imply evolution. At least it seemed to do so to Darwin. But the Kantian philosophy in which this theory was embedded kept its keenest adherents, especially its chief sponsor Muller and Darwin's colleague and later bitter enemy Owen, from drawing evolutionary conclusions. Central to the vitalist materialist view of the germ was that in the course of development the germ expended its primordial "life force." The explanatory problem vitalist materialism posed to Darwin was that any analogy between micro individual and macro species development directly implied that complex, highly developed species, having expended the primordial life force of their germs in development, would promptly become extinct! Based on his own microscopical studies of granules that were closely similar in both plant and animal reproduction, Darwin cut the Gordian knot of this dilemma by a modified vitalism of his own. Darwin simply denied that the life force was expended by development. His view allowed him to appropriate the developmental aspect of vitalist materialism, which he needed for his parallel with macroevolution, while avoiding the undesirable consequence of extinc-

tion."[12] Darwin later dropped this line of thought, or held it in abeyance, when he developed his theory of natural selection.

The second variant of his generation theory was his incorporation of Lamarck. Darwin was led to Lamarck by his interest in understanding the precise means by which the changing environment and the living organism interacted. His increased theoretical appreciation of the relation between reproduction and environment in turn encouraged his reading of the literature of domestic breeders. Lamarck's influence on Darwin is seen most clearly in the phrase "changes of habit precede changes in structure."[13] To the extent that there was any difference between Darwin and his French predecessor, it was one of emphasis. Where Lamarck stressed the conscious will of the animal, Darwin emphasized how environmental change automatically brought about changes in the "habits" of organisms. Scientifically, Darwin's incorporation of Lamarck into his own theory underscored his belief that animal psychology held the key to evolutionary change[14]; rhetorically, Darwin's subsumption of Lamarck was a further instance of his search for acceptable premises that would advance the argument for evolution.

Darwin's Two Theories of Natural Selection

As with each of the previous developments of Darwin's thought, the emergence of his theory of natural selection was the result of an opportunity that opened unexpectedly, not of an ineluctable logic or of a missing piece of a puzzle that fell suddenly in place. Darwin was not searching for a theory of evolution in his transmutation notebooks. He was refining and shoring up a theory he had discovered already. In notebook "D," he observed: "State broadly scarcely any novelty in my theory, only slight differences, the opinion of many people in conversation. The whole object of the book is its proof." (D 69) A few pages later, when he was reading Malthus, Darwin's thought took a dramatic new turn:

> Even the energetic language of Decandolle does not convey the warring of the species as inference from Malthus. . . . I do not doubt every one till he thinks deeply has assumed that increase of animals exactly proportionate to the number that can live. — ..
>
> Population is increase at geometrical ratio in FAR SHORTER time than 25 years — yet until the one sentence of Malthus no one clearly perceived the great check amongst men. . . . Even a *few* years plenty, makes population in man increase & an *ordinary* crop causes a dearth. . . . One may say there is a force like a hundred thousand wedges trying [to] force every kind of adapted structure into the gaps in the oeconomy of nature, or rather forming gaps by thrusting out weaker ones. — / (D 134e-135e)

The expression "adapted structure" signals that what Darwin initially found in Malthus was not a new theory, but a dramatic new argument further supporting his previous theory of automatically adaptive variations! What Darwin initially saw in Malthus's principle of *intra*specific competition was a better explanation of how animals overcame the Lyellian *inter*specific competition that limited them to a specific region where, were it not for the presence of other animals, they might thrive equally well — or of how they avoid extinction when their habitat changed — by migrating.[15] Darwin's first response to Malthus was not to abandon his previous theory and formulate a new one, but to incorporate Malthus into the structure of his sexual generation

theory as a new strategy of exposition, the same way he had earlier incorporated Lyell, Muller, and Lamarck. Only gradually in the weeks and months that followed did Darwin realize that, given Malthus's population dynamics, variations were only differentially, not immediately, adaptive, and that what he had in Malthus was not a new strategy of argument, but a radically new, and as yet unnamed, theory.

By late autumn and early winter of 1838–39, Darwin had derived a new theory of evolution and faced a new challenge of invention. In affirming differential adaptation, Darwin had broken with a significant cultural and theological premise that had made his sexual theory so plausible for so long — the idea of direct providential direction. For a culture accustomed to seeing everywhere in nature the marks of providential foresight, power, and goodness, differential adaptation would seem ridiculous. It is hardly to be wondered that Darwin, who in each of his theories was careful to present his views as implications of already accepted premises, would feel this breach in social logic acutely.

At first, following his rereading of Malthus — at the end of notebook "D" — Darwin drew no explicit connection between Malthus's population dynamics and the practice of domestic breeding. Then, late in notebook "E," Darwin drew his fateful analogy:

> It is a beautiful part of my theory, that domesticated races of organics are made by precisely [the] same means as species — but latter far more perfectly & infinitely slower. (E 71)

Darwin's initial connection between Malthus and evolution in nature, expressed under the far different image of "a hundred thousand wedges," is not clarified in this passage; it is displaced. Darwin's "a hundred thousand wedges," or Wallace's later comparison of the Malthusian process to the "centrifugal governor on a steam engine,"[6] have far more in common with one another than with any analogy based on a goal-directed activity such as domestic breeding. In effect what Darwin discovered in this passage was not the answer to a problem in theoretical biology, but a response to a problem of persuasive exposition he deemed central to the success of his latest theoretical insight.

In his "Sketch" of 1842 and again in his larger "Essay" of 1844, Darwin exaggerated his personification of domestic breeding as the engine of evolution. Darwin asked the reader to imagine whether "a being infinitely more sagacious than man (not an omniscient creator)" given "thousands and thousands of years," could "select all the variations which tended toward certain ends…greyhound produced."[7] In the 1844 "Essay," Darwin wrote: "Let us now suppose a Being with penetration to perceive difference in outer and innermost organization quite imperceptible to man, and with forethought extending over future centuries….I can see no conceivable reason why he could not form a new race or several…adapted to new ends."[8] As these passages show, the Malthusian process of random sifting, having failed rhetorically to supply an appropriate bridge linking nature with social knowledge, was replaced with a non-Malthusian image that occupied the same semantic space as his conceptually failed generation theory — a semantic space midway between mechanism and miracle. By linking his new theory with the images and topics of his old ones, Darwin preserved the informal logic that gave his case for transmutation, under one explanatory mechanism or another, its social force.

Though the fact is not generally known outside Darwin scholarship, Darwin's initial theory was markedly different from the mature theory of natural selection published in the *Origin*. Indeed, Ospovat has argued that Darwin developed two distinct the-

ories of natural selection. Unlike the theory of the *Origin*, Darwin's first theory of natural selection did not present natural selection as an incessantly active process, but only as an intermittent one. Natural selection came into play, according to Darwin's first theory, only after geological change had made the adaptation of animals and plants to their environment imperfect. Indeed, Darwin was not even fully convinced that there was sufficient variation in nature to make natural selection a viable explanation of adaptation! Further, while Darwin certainly believed progress had been the rule over biologic time, his theory of the mid-1840s does not provide a biological foundation for progress, but only an account compatible with it. Degeneration and loss of complexity would be an equally tenable result given the framework of Darwin's assumptions.[49]

For nearly 10 years following his composition of his big 1844 essay, Darwin set aside his evolutionary speculations, and from the mid-1840s until late 1854 focused on his monumental project of describing fossil and living barnacles. On completion of his volumes on barnacles, Darwin returned to his species work because his friend and mentor Charles Lyell had seen an evolutionary essay "On the Law Which Has Regulated the Introduction of New Species" by Alfred Russell Wallace, and warned Darwin that if he did not publish his theory of evolution, someone else would. Wallace's fateful letter to Darwin four years later in June 1858 nearly proved Lyell right.[50] As Darwin reassembled his notes and manuscripts in late 1854 and early 1855 and once again immersed himself in the literature of his peers, he discovered that his earlier views no longer corresponded to the latest advances in biology. In particular, the work of the French biologist Milne Edwards challenged Darwin's environmentally dependent views of species change. Edwards had found that 1) large genera seemed to produce the greatest amount of divergence from their parent type, and 2) there seemed to be a link between divergence and specialization.[51] The uniform character of these phenomena clearly indicated that they were rooted in a biological dynamic and were not biological responses to environmental change.

At first Darwin attempted to salvage his earlier theory by arguing that even a small amount of geological change could release a large stream of variation. Finally, he abandoned the geological response model entirely and thereby freed variation and selection to operate independently of geological constraints. In his proposed chapter on geological distribution in *Natural Selection*, the work he abandoned when he received Wallace's letter, Darwin in the summer of 1856 noted, "Forms of being are infinitely more related to each other" than to "physical conditions." A "place" was now more a biological than a geological concept, and adaptation was only as complete as conditions would allow.[52] Darwin completed the final segment of his path to his mature theory neither primarily by conducting fresh experiments nor by logically working through the implications of his earlier ideas, but by the inventional process of taking the facts and interpretations of his colleagues for granted and subsuming them under his new and revised version of natural selection. In adapting his ideas to the latest findings of his colleagues, Darwin discovered his mature theory.

Conclusion

Several implications for our understanding of the Darwinian revolution follow from our analysis of the role of colloquial language and prudential reason in Darwin's quest for a theory of evolution.

First, though we remember Darwin as the originator of a concept and our contem-

porary texts purport to reduce that concept to a formula, "natural selection" is not merely or even primarily a technical term and thus cannot be understood accurately apart from the circumstance for which it was designed. Though Darwin sought universal scientific generalizations and not merely tactics to encompass situations of local and temporary interest only, Darwin's inventional logic had to be adequate to his explanatory needs in their actual, rhetorically situated complexity. As "natural selection" is a semantic and cognitive halfway house between miracle and mechanism, Darwin's achievement in coining it was not so much to rout received common sense and the Biblical story of origins as reroute them, thereby clearing a cognitive space within convention for a new norm of scientific reason. Darwin's achievement was thus as much cultural as cognitive; as much theological, aesthetic, and commonsensical as abstractly rational. Considered as a triumph of reason, Darwin's achievement was an intervention in the interest of science across the warp and woof of a particular culture at a particular place and time. Resituating as it did the Genesis account alongside a new scientific narrative as the received story of origins for European humanity, Darwin's revolution did not and could not take place in a scene of pure thought, but on the field of essentially contested concepts. Precisely because Darwin's theory of natural selection, in its final versions as in its preselectionist stages, involved a revolution in culture in the interest of a revolution in science, to reduce Darwin's theory to an algorithm and to claim that algorithm as the core of his achievement is inaccurate historically and antirhetorical.

Second, our analysis of Darwin's inventional logic challenges us to expand our conception of scientific reason to include timing and a sense of the appropriate. Darwin's logic, starting with his reading of Lyell on the *Beagle* and continuing through the *Origin*, was always situated in the midst of a living, ongoing, practical task, and this made it at once inadvertent and intentional, opportunistic yet rational. Darwin's reason was inadvertent — or dialectically ironic — in that both before and after his conversion to evolution, and before and after his coining of "natural selection," he frequently thought he was proving one thing when his arguments ended by convincing him of something else. Darwin's logic was intentional, in that from the first, and continuously throughout the various stages of his career, he was ambitious for scientific success and readily seized every opportunity that the voyage, the heuristic resources of Lyell, and the turns of his own thought and experience opened to better make sense of nature. In both its inadvertent and intentional dimensions, Darwin's thought was thoroughly rational — in a rhetorical and inventional sense. Darwin's thought was rational because it was an extension of the action and passion of practical life, where no fixed method will guarantee success and where the defining task of reason is to seize different and sometimes incompatible modes of argument to better grasp the range of the possible and the productive.

Third, our analysis challenges the received notion that clarity or univocacy is the norm or goal of scientific language. Darwin's rhetorical genius was never more in evidence than in his ability to select terms, turns of phrase, and lines of argument that suggest or echo meanings they neither explicitly affirm nor deny. From Darwin's initial use of the term "halo effect" in his first note on transmutation to the theistic "halo effect" of the term "natural selection," there is a playful yet serious irony that runs the length of Darwin's evolutionary works. Darwin's language functions not to resolve decisively, but to renegotiate radically and in the interests of science a traditional cultural tension between scientific intelligibility and religious awe. That the *Origin* also, and notoriously, accents the competitive features of its cultural milieu

while remaining in the strict sense a *major* work of science is but a *further* example of Darwin's ability to use common sense to restructure common sense. That the cognitive victory won through such language would come heavily mortgaged to prereflective habits of thought should not for a moment diminish the epochal nature of Darwin's achievement, but make us mindful of its foundation in inventional genius.

Finally, our analysis challenges whatever epistemological remnant may yet remain of the neopositivist Berlin Wall separating the context of discovery from the context of justification. When at one point Wallace pleaded with Darwin to drop "natural selection" as fundamentally misleading to their mutual insight into Malthus, Darwin accepted most of Wallace's objections, but urged that the term was now public and must survive or perish by the "natural selection" that operated on language.[33] Peter Vorzimmer's study of the six editions of the *Origin* shows that Darwin in fact progressively moved away from natural selection and supplemented it with other preselectionist arguments in proportion as it failed to persuade. The first image Darwin jettisoned was conceptually his most accurate and chronologically the first suggested by his reading of Malthus — his image of population pressure as "ten thousand sharp wedges packed closely together."[34]

If the present analysis and the technical scholarship to which it is indebted demonstrates a single point about the connection between Darwin's language and his reasoning, it is this: any attempt to distinguish Darwin's process of "discovery" from his process of "justification" on the ground that the former is private, subjective, and imaginative (that is, "irrational") while the latter is public, objective, and falsifiable is itself falsifiable, for in setting aside Darwin's language, it cannot account for his reasoning. Our investigation of the development of Darwin's ideas as the unfolding of a series of inventional strategies argues that fruitful and sustained ambiguity is not an exception to Darwin's genius, but its very essence. As for the "public" character of Darwin's thought (even in his notebooks), the conclusions of the present study, along with the earlier work of Rudwick and Manier, are massively supported but DeGregorio's soon-to-be-released three-volume project on Darwin's marginalia.[35] It can now be said that virtually every note Darwin penned, at least those that survive, was written with an eye to a public, often in response to a nameable individual. As for Darwin's "imagination," we have found no difference in the imagistic depth of Darwin's initial discarded theories and the imagistic scope of his mature theory of "natural selection." Indeed, many of the preselectionist images of the notebooks were continued in the *Origin*.

If one might wonder how to square Darwin's unshakable reputation as a theorist with the remarkable conceptual suppleness of his scientific theories, the preceding analysis offers a partial explanation. Both before and after the *Origin*, Darwin originated not so much a theory as a family of theories, each with distinct species and subspecies, and each in response to a particular occasion. What is at risk among his various theories is less a matter of truth or falsity as of decorum — of which Darwin in biology, no less than Cicero in forensic oratory, was the absolute master. From his first jotting in his first notebook through his sixth and final edition of the *Origin*, scientific discovery and rhetorical invention, technical and social reason, concept and image so effectively unite in Darwin's thought that one can only say each is an aspect of a flexible logic of inquiry and presentation.

Notes

1. Charles Darwin, *On the Origin of Species, A Facsimile of the First Edition* (New York: Atheneum, 1967), vii. All subsequent references to the *Origin* will be to this edition unless otherwise indicated.

2. Charles Darwin, *The Red Notebook of Charles Darwin*, ed. Sandra Herbert (Ithaca: Cornell University Press, 1980), 6–17.

3. Francis Darwin, ed., *The Life and Letters of Charles Darwin* (New York: D. Appleton & Co., 1911), vol. 1: 511.

4. *Origin*, 83–84.

5. Stephen Jay Gould, *Ever Since Darwin* (New York: W. W. Norton & Co., 1977), 11.

6. For an account of the distinctions among algorithmic, heuristic, and prudential thinking, see Eugene Garver, *Machiavelli and the History of Prudence* (Madison: The University of Wisconsin Press, 1987), 6–22.

7. Charles Darwin, *The Origin of Species*, 6th ed. (New York: Collier Books, 1972), 91–92. For a detailed analysis of this metaphor, see John F. Cornell, "Analogy and Technology in Darwin's Vision of Nature," *Journal of the History of Biology* 17 (Fall 1984): 303–44.

8. John Angus Campbell, "Scientific Revolution and the Grammar of Culture: The Case of Darwin's *Origin*," *Quarterly Journal of Speech* 72 (November 1986): 358–66.

9. For Darwin's early notebooks, see Paul H. Barrett, Peter J. Gautry, Sandra Herbert, David Kohn, Sydney Smith, eds., *Charles Darwin's Notebooks, 1836–1844: Geology, Transmutation of Species, Metaphysical Enquiries* (Ithaca: Cornell University Press, 1987). Especially for the sketch of 1842 and the essay of 1844, see Gavin DeBeer, ed., *Evolution By Natural Selection* (Cambridge: Cambridge University Press, 1958). For Darwin's abandoned book on species, see R. C. Stauffer, *Charles Darwin's 'Natural Selection,' being the second part of his big species book written from 1856 to 1858* (London and New York: Cambridge University Press, 1975). For works interpreting the stages of Darwin's thought, see Sydney Smith, "The Origin of 'The Origin,'" *Advancement of Science* 16 (1960): 391–401; *Origin*, op. cit.; David Kohn, "Theories to Work By: Rejected Theories, Reproduction, and Darwin's Path to Natural Selection," *Studies in the History of Biology* 4 (1980); M.J.S. Hodge and David Kohn, "The Immediate Origins of Natural Selection," in David Kohn, ed., *The Darwinian Heritage* (Princeton: Princeton University Press in association with Nova Pacifica, 1985), 185–206; Dov Ospovat, *The Development of Darwin's Theory: Natural History, Natural Theology and Natural Selection* (Cambridge: Cambridge University Press, 1981); Frank Sulloway, "Darwin's Conversion and Its Aftermath," *Journal of the History of Biology* 15 (February 1982): 325–96; M. J. S. Hodge,

"Darwin and the Laws of the Animate Part of the Terrestrial System (1835–1837): On the Lyellian Origins of His Zoonomical Explanatory Program," *Studies in the History of Biology* 7:1–106; Philip R. Sloan, "Darwin, Vital Matter, and Transformism of Species," *Journal of the History of Biology* 19 (Fall 1986): 369–445.

10. Hodge, 70.

11. Sulloway, 346–51.

12. Ibid., 357–51.

13. Noral Barlow, ed., "Darwin's Ornithological Notes," *Bulletin of the British Museum (Natural History)*, Hist. Ser., 2, no. 7 (1963): 262.

14. Sulloway, 351.

15. Howard E. Gruber, *Darwin on Man*, 2d ed. (Chicago: University of Chicago Press), 73–93; Sloane, 369–400.

16. Hodge, 15–16.

17. Charles Lyell, *Principles of Geology*, vol. 1, with a new introduction by Martin J. S. Rudwick (Chicago: University of Chicago Press, 1990); see especially introduction, vii-lv. Also, Martin J. S. Rudwick, "The Strategy of Lyell's *Principles of Geology*," *Isis* 61: 5–33; Hodge, 6–15.

18. Rudwick, 6–15; Hodge, 28–35.

19. Chaim Perelman and L. Olbrechts-Tyteca, *The New Rhetoric: A Treatise on Argumentation* (Notre Dame: University of Notre Dame Press, 1969), 115–20, 357–60. For a fuller discussion of Lyell and this figure, see John Angus Campbell, "Of Orchids, Insects and Natural Theology: The Evolution of Darwin's Strategy After the *Origin*," in Bruce Gronbeck, ed., *Spheres of Argument: Proceedings of the Sixth Annual SCA/AFA Conference on Argumentation* (Speech Communication Association, Annandale, Virginia, 1989): 217–18.

20. Hodge, 11–12.

21. Ibid., 20–22.

22. Ibid., 55.

23. Ibid., 16.

24. Cited in Hodge, 20.

25. For a full discussion of Darwin and the issues of a limit to the life of species, see Sloane, op. cit. Also, Hodge, 22–28.

26. Kohn, "Theories to Work By," 56–57.

27. Ibid., 57.

28. Cited in Hodge, 57–58. See also Lyell, 526–27.

29. Hodge, 49.

30. Ibid., 28–35.

31. Ibid., 60.

32. Ibid., 60–66.

33. Ibid., 64.

34. John Angus Campbell, "Scientific Discovery and Rhetorical Invention: The Path to Darwin's *Origin*," in Herbert W. Simons, ed., *The Rhetorical Turn* (Chicago: University of Chicago Press, 1990), 58–90.

35. For Darwin's activities immediately following the voyage, see Herbert, 5–19; Martin Rudwick, "Charles Darwin in London: The Integration of Public and Private Science," *Isis* 73: 186–206; Sulloway, 356–86; Sloane, 420–44. On his key strategic decisions, see Hodge, 43, 66–80.

36. On the writing of Darwin's *Journal* following the voyage, see Hodge, 43. Humboldt's *Personal Narrative* had originally inspired Darwin to want to take a round-the-world voyage. Darwin read Humboldt so much while writing his *Journal* that his sister Caroline complained his style was too close to that of his model. Frederick Burkhardt et al., eds., *The Correspondence of Charles Darwin*, vol. 1 (Cambridge: Cambridge University Press, 1985), 345.

37. Barret, Gautrey et al., *Darwin's Notebooks*, 61. All subsequent references to the notebooks will be by line number and will be given in the text.

38. Sloane, 383–99.

39. Kohn, "Theories to Work By," 79–81.

40. John Angus Campbell, "Scientific Discovery and Rhetorical Invention," 62–85.

41. Ibid. Also Kohn, "Theories to Work By," 79–87.

42. Philip R. Sloane, "Darwin, Vital Matter and the Transformation of Species," 369–99. Also, Timothy Lenoir, *The Strategy of Life* (Chicago: University of Chicago Press, 1982).

43. Kohn, 129–33. See also George Grinnell, "The Rise and Fall of Darwin's Second Theory," *Journal of the History of Biology* 18 (Spring 1985): 51–70.

44. For the relationship of Darwin's notebooks to one another, see Sandra Herbert and David Kohn, introduction in Barrett, Gautrey et al., 6–12.

45. Kohn, 142–49; Hodge and Kohn, 193–97; Ospovat, 56–57, 196.

46. Ibid., DeBeer, 278.

47. Ibid., 45.

48. Ibid., 114.

49. Ospovat, 1–5, 191–223.

50. For an account of the Darwin and Lyell relationship, see John Angus Campbell, "The Invisible Rhetorician: Charles Darwin's 'Third Party' Strategy," *Rhetorica* 7 (Winter 1989), especially 56–63.

51. Ospovat, 115–45, 146–69, 175–76, 181, 201.

52. Ospovat, 218–23.

53. Francis Darwin, ed., *More Letters of Charles Darwin*, 2 July 1866, vol. I, 267.

54. Peter Vorzimer, *Charles Darwin: The Years of Controversy: The Origin of Species and Its Critics 1859–1882* (Philadelphia: Temple University Press, 1970), 6–7, 269–71; Morse Peckham, ed., The Origin of Species *by Charles Darwin: A Variorum Text* (Philadelphia: University of Pennsylvania Press, 1959), 150.

55. Mario DiGregorio and Nick Gill, *Darwin's Marginalia* (Cambridge: Cambridge University Press, 1991). Professor DiGregorio kindly allowed me to examine a prepublication copy.